



Department of Agriculture and Food



**Key Information on Smoke Effect in Grapes and Wine:
What can be done to identify and reduce smoke effect in grape and wine
production?**

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INTRODUCTION

Smoke exposure to grapevines and the development of smoke-related characteristics in resultant wines is an issue of increasing incidence and severity for the wine industry nationally and internationally. As Australia faces a warming climate with an increase in bushfire incidence, smoke exposure to vineyards is becoming a more regular occurrence. Where grapevines are exposed to smoke during sensitive periods of grapevine growth and development the resultant wine may be unfit for purpose.

Wines made from grapes exposed to smoke during sensitive growth stages can exhibit ‘smoked meat’, ‘disinfectant’, ‘leather’, ‘burnt’, ‘smoky’, ‘salami’ and ‘ashtray’ aromas and flavours. Where unfavourable smoke characteristics are detected by consumers at high concentrations the resultant wine may be unpalatable and unfit for purpose. Unsalable wines result in financial losses for wine producers with costs on-flowing to wine brands, market presence and future wine sales.

This publication details key information on the smoke effect issue, tools and techniques for smoke reduction within the vineyard, winery and options for laboratory analysis. This document has been compiled directly in response to smoke events in the south-west of WA. Additional comprehensive documents detailing smoke effect are currently in production.

Grapevine seasonal sensitivity to smoke uptake

Of importance to understanding the effects of smoke exposure on grapevines and the development of smoke characteristics in wine is knowledge of the timing of grapevine sensitivity to smoke uptake. That is, when during the growing season are grapevines sensitive and susceptible to smoke uptake?

Research was conducted with Merlot grapevines over 3 seasons where they were exposed to smoke at the key growth stages of shoots 10 cm, flowering, berries pea size, beginning of bunch closure, veraison, grapes with intermediate sugar, berries not quite ripe and harvest to understand the level of smoke related characteristics in the final wine (Kennison et al. 2011). Research results show three key periods of grapevine sensitivity to be identified as:

1. from the period of shoots 10 cm in length to flowering: grapevines are low in their sensitivity to smoke
2. from the period of berries pea size through to 3 days post veraison: grapevines are variable (low to medium) in their sensitivity to smoke
3. from the period of 7 days post veraison to harvest: grapevines are highly sensitive to smoke (Figure 1).

Smoke exposure to grapevines can also result in the delay of fruit ripening. On a number of occasions, studies have shown fruit from smoke exposed vines to have a lower sugar content in comparison to fruit from unsmoked vines (Kennison et al. 2009a). The delay in ripening is thought to be related to the effect of smoke on the functioning of the grapevine, with further studies investigating the photosynthetic response of grapevines to smoke exposure.

Figure 1. Key periods of grapevine sensitivity to smoke exposure and the development of subsequent smoke aromas and compounds in wine. Information is derived from 3 years of research investigating the direct application of smoke to field grown Merlot grapevines.

	Grapevine growth stage	Potential for smoke uptake
P1	Shoots 10 cm in length	Low
	Flowering	Low
	Berries pea size	Variable (low to medium)
P2	Beginning of bunch closure	Variable (low to medium)
	Onset of veraison to 3 days post veraison	Variable (low to medium)
P3	From 7 days post veraison to Harvest	High
	Harvest	

Smoke effect on grapevine varieties

Recently, the effects of smoke uptake and development have been found to vary depending on the grapevine variety. Previous studies have focused on the effects of smoke application to one grapevine variety only (Merlot). These studies of smoke application to Merlot were comprehensive as they were conducted over a three year period. However, further studies have investigated the effect of smoke on other grapevine varieties including Cabernet Sauvignon, Chardonnay and Sauvignon Blanc. These studies have found the timing of smoke uptake to vary with different varieties. For example, some varieties may differ in their sensitivity to smoke uptake when compared with others.

The difference in smoke uptake between wine grape varieties may be due to a number of reasons. These may include the difference in seasonal weather conditions and vine health. Wine grape varieties can differ in plant structure in aspects such as berry skin thickness which may also possibly affect smoke uptake and development. Winemaking techniques can also influence the smoke effect development in the final wine. For example, white wines have been found to have less smoke related sensory and chemical aspects due to a reduced fermentation time on skins in comparison to red wines.

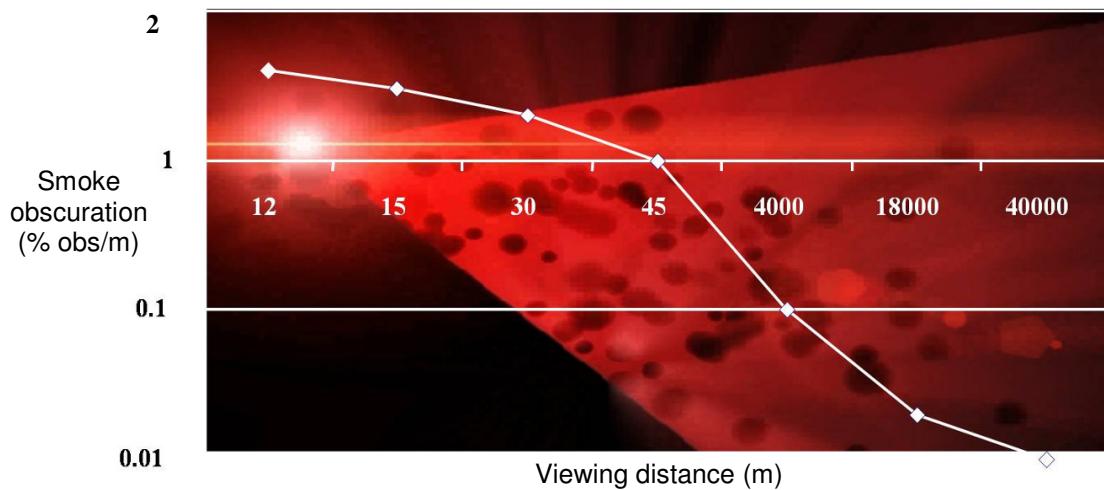
How much smoke creates smoke effect in wine?

What is the quantity of smoke exposure to grapevines that is required to create smoke effect in grapes and wine? In order to answer this question, extensive field research was conducted by DAFWA. This research employed the field-based smoke detecting (nephelometry) equipment to measure the density and duration of smoke that was applied to grapevines. Essentially, the smoke detecting device measured smoke in units of obscuration per meter (% obs/m). This relates to the impairment of normal vision over a distance of 1 meter. A visual description of smoke obscuration per meter and the associated viewing distance is provided in Figure 2. In field research smoke was applied to grapevines at various smoke densities (2.5, 5, 10, 20 and 30% obs/m) and durations (from 5 min up to 80 min). Smoke applications were made during grapevine growth periods that have been defined as sensitive for smoke uptake by grapevines.

Results showed a single heavy smoke exposure (30% obs/m) for 30 min applied at a sensitive stage of vine growth (from 7 days post veraison to harvest) was sufficient to create smoke effect in wine (Kennison et al. 2008). Lower smoke densities for shorter durations also applied at a sensitive vine growth stage can create a difference in the wine as detectable by wine consumers (Kennison et al. 2012). Whereas smoke effect characteristics such as smoke-like aromas and flavours are pronounced in wines produced from high smoke densities (20% obs/m) for short durations and low smoke densities (2.5% obs/m) for long durations. It is important to note that grape harvesting, handling and winemaking techniques can influence the creation of smoke effect in wine. Techniques to reduce smoke effect in grapes and wine are detailed further in this document.

The effect of repeated smoke applications to the same vines has also been investigated. Research was conducted where 8 repeated smoke treatments were applied to the same Merlot vines throughout the growing season. Wine sensory and chemical analysis showed the smoke to have a cumulative effect on the levels of smoke-related compounds and aromas (Kennison et al. 2008). Therefore, repeated smoke exposures or smoke exposures for a long period of time result in the accumulation of smoke aromas and compounds in the final wine.

Figure 2. Viewing distance (in metres) as per the level of smoke obscuration (% obs/m as determined by nephelometry)



Carry-over of smoke-related characters from one year to another?

Can grapes absorb smoke compounds within a season, store these compounds and release them into fruit in the subsequent season? Research was conducted where grapevines were exposed to 8 repeated smoke applications from the grapevine growth period of veraison through to harvest (Kennison et al. 2011). Wine was made from smoke exposed fruit and found to contain clear smoke-related characters including elevated levels of 'smoked meat', 'burnt rubber', 'leather' and 'disinfectant / hospital' aromas. One year subsequent to the repeated smoke application, fruit from the same vines was harvested, made into wine and evaluated for the presence of smoke aromas. Smoke effect was not found to carry-over in wine in the season that followed the high smoke exposure, however the fruit yield was found to be reduced. The fruit yield, one year post repeated smoke applications, was found to be considerably lower (6.4 kg) in relation to fruit yield from those wines that were not exposed to smoke (12.9 kg). The repeated smoke exposure was therefore likely to have an effect on the functioning of the grapevine and reproductive capability.

Smoke effect on wine production

Wine production with smoke exposed fruit can be different to wine production with unsmoked fruit and a number of tools and techniques can be employed to reduce smoke effect throughout the winemaking process. Smoke-related volatile phenols have been shown to accumulate in musts during fermentation and further still after malolactic fermentation (Kennison et al. 2008). These smoke-related volatile phenols can be reduced depending on how the fruit is handled and how the wine is fermented.

Generally, the fermentation of grape musts is accelerated with smoke affected grapes and the smoke-related volatile phenols accumulate in the bottle over time (Kennison et al. 2008). A number of ‘techniques to reduce smoke effect’ in wine have been indentified and are detailed further in this publication.

Smoke effect reduction system

A comprehensive computer based tool is currently being developed by DAFWA and the University of WA in order to reduce the incidence and severity of smoke on grape and wine production. The tool has been developed in order to predict the seasonal vine phenological stage of development and the associated susceptibility of the vine to smoke uptake and development. The tool can also be applied for use in decision making for prescribed burning practices. It is aptly named the Smoke Risk Calculator (‘STAR’) and will be available for access by June 2012. ‘STAR’ incorporates a number of elements to reduce the risk of smoke exposure and development. These include vineyard location mapping, knowledge of seasonal grapevine growth stages, smoke risk factors, in-field smoke detecting equipment and an interactive software interface.

IN CASE OF A SMOKE EVENT IN THE VINEYARD...

Smoke events in the landscape can be frequent and arise from a number of sources. It would be ideal to avoid long, dense durations of smoke exposure to grapevines during fruit production however this is not always possible in the Australian landscape. It is therefore imperative that actions and techniques to practically reduce the negative effects of smoke exposure to wine grapes are developed. These actions can be of use if a smoke event is imminent and if a smoke event has occurred.

Sampling / sending / testing of grapes

If a smoke event has occurred, an option is to have wine grapes tested for the presence of the smoke-related marker compounds guaiacol and 4-methylguaiacol. Samples can include grapes, juice, leaves and wine. Testing of grapes and juice for the presence of smoke-related compounds of guaiacol and 4-methylguaiacol provides an indication of whether the fruit has been exposed to smoke. Low levels of guaiacol and 4-methylguaiacol may be naturally present in fruit with these levels elevated in smoke exposed fruit. Guaiacol and 4-methylguaiacol detection in fruit can not be used as a determinant of the smoke effect intensity in the final wine as this is influenced by fruit handling and processing procedures. If you are concerned that grapes may have been affected by smoke even at very early growth periods sampling is best done from 2 weeks before anticipated harvest. Testing is ineffective on grapes sampled at earlier stages. Testing laboratories may provide an interpretation of test results however a 'bench-top' or 'small-lot' fermentation of grapes conducted prior to harvest is suggested to provide an indication of effect intensity in final wines. Research is currently ongoing to determine a more effective analysis of grapes for the presence of smoke-related characters.

Grapevine samples should be collected early in the day prior to high temperatures and vine stress. Samples should encompass a representation of the vineyard area and be collected in a randomised method. Samples should be kept cool and frozen if to be posted out of WA. A number of laboratories offer testing with many of these located in the Eastern States. A Plant Health Certificate is required for movement of plant material from WA to the Eastern States.

Please note: a central collection and distribution point for the sending of samples from WA to laboratories in the Eastern States will be available in early 2012.

Techniques to reduce smoke effect in grapes and wine

Subsequent to smoke exposure to field-grown grapevines, a number of techniques can be employed in both the vineyard and winery in order to reduce the concentration of smoke related aromas, flavour and compounds in the final wine. Many of these techniques have been detailed below.

Technique	Details
Hand harvest fruit	Minimise breaking or rupturing of the skins as long as possible ^{1,2}
Exclude leaf material	Grapevine leaf material can contribute smoke related characteristics when in contact with fruit and juice ^{1,2}
Leaf plucking and water wash of grapevines	Canopy leaf plucking followed by high-pressure cold water wash in the vineyard can remove ash ⁷ however water wash to entire canopy (including leaves) can accentuate smoke compounds in fruit ⁸
Maintain integrity of harvested fruit	Fruit maceration and skin contact with juice can lead to higher concentrations of smoke-related compounds ²
Keep fruit cool	Fruit processed at 10°C had less extraction of smoke-related compounds compared to fruit processed at 25°C ^{1,2}
Whole bunch press	Has been shown to reduce the extraction of smoke derived compounds particularly in whites ^{1,3}
Separate press fractions	Smoke characters could be minimised in the first 400L/t when combined with fruit cooling; free-run juice can contain less smoke characters ^{1,2,3}
Conduct fining trials pre-fermentation	Carbon, PVPP and isinglass have shown variable effectiveness in reducing smoke effect but are not selective; fermentation management requires further consideration post fining ^{1,2,3}
Consider yeast selection	Some yeast strains have been shown to alter smoke-related aromas, flavours and chemical composition of wine ⁴
Minimise fermentation time on skins	Wine fermentation that reduces skin contact time is shown to reduce smoke aromas and flavours ^{1,4,5}
Consider addition of oak chips and tannin	Have been found to reduce intensity of smoke effect through increased wine complexity ⁴
Reverse osmosis of wine	Has been found to be effective in smoke effect reduction however smoke-related characteristics found to return in the wine over time ⁶
Market wine for immediate consumption	Evolution of smoke related characteristics can occur in bottle over time as wine ages therefore early consumption is recommended ^{1,3,6}

¹Simos 2008, ²Whiting and Krstic 2007, ³Ulrich 2009, ⁴Ristic 2011, ⁵Kennison et al. 2008, ⁶Fudge et al 2011, ⁷Høj et al. 2003, ⁸Kennison 2009b

REFERENCES

Fudge, A.L., Ristic, R., Wollan, D. and Wilkinson, K.L. (2011) Amelioration of smoke taint in wine by reverse osmosis and solid phase adsorption. *Australian Journal of Grape and Wine Research* 17(2), S41-S48.

GWRDC (2009) Smoke effects in grapes and wine: managing quality in a changing climate. *Grape and Wine Research and Development Corporation, South Australia*.

Høj, P., Pretorius, I. and Blair, R. Eds. (2003) *The Australian Wine Research Institute Annual Report 2003*. (The Australian Wine Research Institute, Adelaide, Australia) pp.37-39.

Kennison, K.R. (2009b) Bushfire generated smoke taint in grapes and wine. Final report to *Grape and Wine Research and Development Corporation, RD 05/02-3*.

Kennison, K.R., Gibberd, M.R., Pollnitz, A.P. and Wilkinson, K.L. (2008) Smoke-derived taint in wine: the release of smoke-derived volatile phenols during fermentation of Merlot juice following grapevine exposure to smoke. *Journal of Agricultural and Food Chemistry* 56, 7379-7383.

Kennison, K.R., Wilkinson, K.L., Pollnitz, A.P., Williams, H.G. and Gibberd, M.R. (2009a) Effect of timing and duration of grapevine exposure to smoke on the composition and sensory properties of wine. *Australian Journal of Grape and Wine Research* 15, 228-237.

Kennison K.R., Wilkinson, K.L., Pollnitz, A.P., Williams, H.G. and Gibberd, M.R. (2011). Effect of smoke application to field-grown Merlot grapevines at key phenological growth stages on wine sensory and chemical properties. *Australian Journal of Grape and Wine Research* 17(2), S5-S12.

Kennison, K.R., Williams, H.G. and Gibberd, M.R. (2012) The density and duration of smoke exposure to grapevines influences the development of smoke-like compounds, flavours and aromas in resultant wine. *Manuscript in preparation*.

Ristic, R., Osidacz, P., Pinchbeck, K.A., Hayasaka, Y., Fudge, A.L. and Wilkinson, K.L. (2011) The effect of winemaking techniques on the intensity of smoke taint in wine. *Australian Journal of Grape and Wine Research* 17(2), S29-S40.

Simos, C. (2008) The implications of smoke taint and management practices. *Australian Viticulture* Jan/Feb 77-80.

Ulrich, T. (2009) When the smoke cleared: California winemakers face tough pre-bottling decisions for 2008 wines. *Wines and Vines*, July 46-52.

Whiting, J. and Krstic, M. (2007) Understanding the sensitivity to timing and management options to mitigate the negative impacts of bush fire smoke on grape and wine quality – scoping study. *Department of Primary Industries Knoxfield Victoria*.